A Hybrid Evaluation Approach for the Emotional State of Information Systems Users

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Abstract: The Human-Computer Interaction community has been discussing ways to consider the user's emotions while interacting with computers. Emotions are a complex phenomenon, are difficult to identify and measure and are linked to several components as cognitive aspects, subjective feelings, behavioral tendencies, physiological responses and motor expressions. In the literature, it is possible to identify various techniques, methods and tools for assessing the user's emotional state. Considering the complexity of the subject, it is necessary to combine methods to minimize the detection of false positives in the evaluation of the user's emotional state while interacting with information systems. This paper presents a hybrid approach based on the emotion model described by Scherer (1984), which allows designers to check whether the information system creates a positive, neutral or negative emotional reaction in the user. A feasibility study was conducted in which an emotional evaluation of a web system was performed based on a group of elderly users using tablet devices.

1 INTRODUCTION

Emotions are a key to understanding human behavior (Cristescu, 2008). They are seen as a mental state that arises spontaneously, without conscious effort, and considered as feelings in general that are often accompanied by physiological changes such as breathing, circulation and secretions. They are also influenced by several external and internal stimuli including the context of the situation, life experience, recent experiences, personality, affect and the cognitive interpretation of these influences (Lim et al., 2008).

Emotions are a complex phenomenon that are difficult to identify and to measure. For psychologists, emotions are linked to the reaction of several components as cognitive aspects, subjective feelings, behavioral tendencies, physiological responses and motor expressions (Mahlke and Mingue, 2008); (Scherer, 2005). Emotions affect our attention, perception, memory, behavior and cognition. Emotional responses are present in all types of interaction between human beings, and they lead us to quickly determine if the elements of the environment we live in are safe or dangerous, or good or bad (Beale and Peter, 2008); (Norman, 2004); (Piccolo et al., 2010). This type of knowledge about emotional responses may explain why people express their feelings while interacting with information systems.

Therefore, it is vital to consider the users' emotional values and their expressions during the design process to allow the information system's interfaces to inspire greater confidence among users as well as for the interface to be easier to learn and use (Jonghwa and Andre, 2008); (Hayashi et al., 2008). In the Human-Computer Interaction (HCI) literature, it is possible to identify methods, techniques and tools for the assessment of users' emotions, (e.g., (Lefevre and Lefevre, 2005); (Axelrod and Hone, 2008); (Cristescu, 2008); (Yusoff and Salim, 2010). However, the separate applications of these approaches may lead to the detection of false positives in the identification of the users' emotional state due the interaction process.

Among elderly users, we observed that in some cases, a bad interaction experience relative to the traditional usability metrics, such as the time of interaction, the number of mistakes or non-concluded tasks, whereas in other cases, the users selected symbols indicating a good emotional

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experience, such as happiness or satisfaction in a self-reported questionnaire. One user stated, “In life, we cannot be sad” and selected a happy face in the questionnaire. Although we agree that usability metrics are not by themselves sufficient for one to judge an interaction experience, in this case, the user considered her life experience in general and did not evaluate the emotional reaction due to her interaction with the system. We argue that it is necessary to combine methods, involving different stakeholders such as users and specialists, to minimize the detection of false positives.

This work presents a hybrid evaluation approach that allows designers to check whether the information system creates a positive, neutral or negative emotional reaction in the users. Our approach, which is based on the emotion model described by Scherer (1984), considers a set of methods that allows designers to identify the emotional state of the user by considering the subjective feelings and physiological reactions with the user’s opinions and reactions as well as the cognitive appraisals, behavioral tendencies and motor expressions. A feasibility study was conducted in which an emotional evaluation of a web system was performed that considered a group of elderly users using tablet devices.

This paper is organized as follows. Section 2 presents the emotion model described by Scherer (1984). Section 3 summarizes some techniques and tools that can be applied to evaluate each component of the model proposed by Scherer. Section 4 describes our hybrid approach aiming to help designers in evaluating the user’s emotional response. Section 5 presents the feasibility study performed to evaluate the proposed approach. Section 6 presents a critical analysis and some of the lessons learned. Finally, section 7 provides the conclusion.

2 MODELS FOR EMOTIONS

The identification of human emotional states is difficult and complex (Cristescu, 2008). Therefore, to try to gain a better understanding of the subject, some models describing how we feel emotions can be found in literature. Some of these models describe the emotions using mainly a cognitive approach (e.g., Ortony et al., 1988), whereas others consider multidimensional aspects as pleasure and arousal (e.g., Osgood et al., 1975; Russell, 1983).

In this work, we have adopted Scherer’s model (1984), which is based on components. According to him, “it is interesting to speculate about the possibility that specific components of emotion are specialized to serve specific functions” (p. 297). Scherer’s model was chosen because its approach based on components allows us to work with each component separately and therefore choose the appropriate methods to evaluate the different dimensions. Moreover, it has been successfully used in other HCI studies to support the investigation of emotional experiences in interactive contexts (e.g., (Desmet, 2003); (Mahlke and Mingue, 2008); (Alonso et al., 2011).

Scherer’s model consists of a triangle, which is connected to two components: cognitive appraisals and behavioral tendencies (Scherer 1984; 2005); (Mahlke and Mingue, 2008). The cognitive appraisals are relevant to the assessment of the environment including the objects and events. This component leads to different emotions depending on the user’s interpretation. In contrast, the behavioral tendencies prepare the user’s emotional reactions. According to Mahlke and Mingue (2008), these reactions can be expressed in several ways, such as the time required for single input operations or completing a defined goal, the accuracy of reaching a goal, the number of errors and the number of creative ideas during interaction with a system. Figure 1 illustrates Scherer’s model.

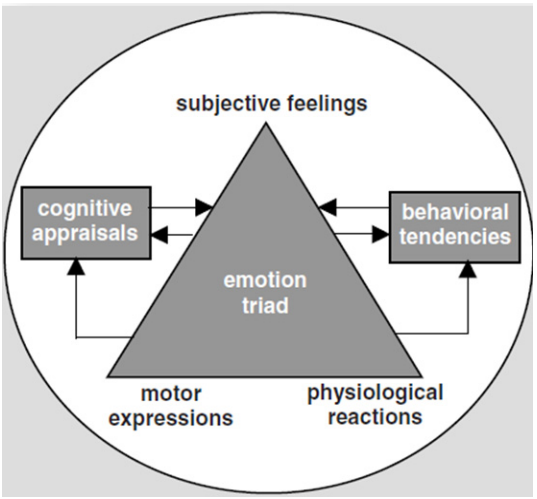

Figure 1: Scherer’s model to describe emotions (Mahlke and Mingue, 2008).

In addition to the cognitive appraisals and behavioral tendencies, Scherer’s model also considers the following:

- Subjective Feelings that monitor the internal state and the organism's interaction with the environment, also known as conscience of emotional

state;

- Motor expressions that communicate reactions and emotional and behavioral tendencies; and
- Physiological reactions that act to regulate the system, determining the activation of neuroendocrine processes (related to the nervous and endocrine influences) such as heart rate, skin conductance, blood pressure, respiration, and pupil dilation (Shami, 2008).

Our approach considers a set of methods that allows designers to identify the user's subjective feelings as reported by the user as well as cognitive appraisals and motor expressions derived from the participation of evaluators.

3 EMOTIONAL EVALUATION

In the literature, it is possible to identify methods, techniques and tools with which to assess emotions in humans. Each of them has features characterizing them more appropriate for certain aspects of emotions. Generally, the instruments applied in the methods, techniques and tools can be classified as verbal or non-verbal. In this research, we consider an instrument as verbal when the user explicitly verbalizes what s/he is feeling.

According to Desmet (2003), verbal instruments enable users to express their emotion in scales (when a user says "I am very happy" or "I am not anxious at all") and to report "mixed" emotions as tension. However, they are difficult to apply across cultures because it may not be easy to translate emotions into words. On the other hand, non-verbal instruments can be considered discreet and independent of culture and language. However, they can be subjective as they generally use universal symbols such as pictograms.

Figure 2 presents a taxonomy, which classifies emotional assessment metrics as verbal or non-verbal. Each final node in the taxonomy represents one of the five components of Scherer's model, and each parent node represents a set of available methods, techniques, tools and instruments that can be used to measure a component.

Cognitive assessments are linked to the interpretation of a situation and further development of emotions. This component can be measured by the Geneva Appraisal Questionnaire (GAF) (Geneva Emotion Research Group, 2010), the Think-aloud method (Someren et al., 1994) and the Subjective Discourse Analysis (Lefevre and Lefevre, 2005). Although the Subjective Discourse Analysis considers spoken statements, this technique was classified as non-verbal because users do not explicitly say what they are feeling. The evaluators should interpret the statements spoken during the user's interaction and classify the related emotion.

According to Scherer (2005) and Desmet (2003), there is no objective method capable of measuring subjective feelings. It is necessary to query the user, and thus, the methods involve self-assessment. Most of the methods for evaluating subjective feelings are non-verbal, such as the SAM (Self-Assessment Manikin) (Lang, 1985), Emocards (Reijneveld et al., 2003), and Preemo (Desmet, 2003). A verbal instrument is the Affect Grid (Russell, 1989).

The motor expressions are related to facial movements, body gestures as well as to some characteristics of speech as speed, intensity, melody and sound. Methods that can be applied include the Facial Action Coding System (FACS) (Ekman et al., 2002), the Ten Heuristics of Emotion (Lera and Domingo, 2007) and electromyography.

Physiological reactions are non-verbal and can be measured by electrocardiogram, respiration rate, electrodermal activity, electromyography, pupillometry, etc. Physiological reactions allow designers to evaluate the user's emotional responses in an experimental context once the users spontaneously and unconsciously reveal their emotions (Cristescu, 2008); (Yusoff and Salim, 2010). However, most of these evaluations require expensive instruments and are intrusive and complex (Axelrod and Hone, 2008); (Cristescu, 2008).

Finally, behavioral tendencies are also non-verbal and generally are evaluated by performance indicators, such as the time required to complete a task, the accuracy of reaching a goal, the number of errors and the number of creative' ideas during the interaction (Mahlke and Mingue, 2008).

4 A HYBRID APPROACH

Aiming to minimize the detection of false positives in the emotional evaluation of information systems, this work proposes a hybrid approach based on the emotion model described by Scherer (1984). Considering the evaluation methods and instruments presented in the literature, we have selected a subset that matches the five components of the Scherer's model. This selection considered the main stakeholder (user or specialist) responsible for the final result of each method or instrument, aiming to balance the final emotional assessment of the information system.

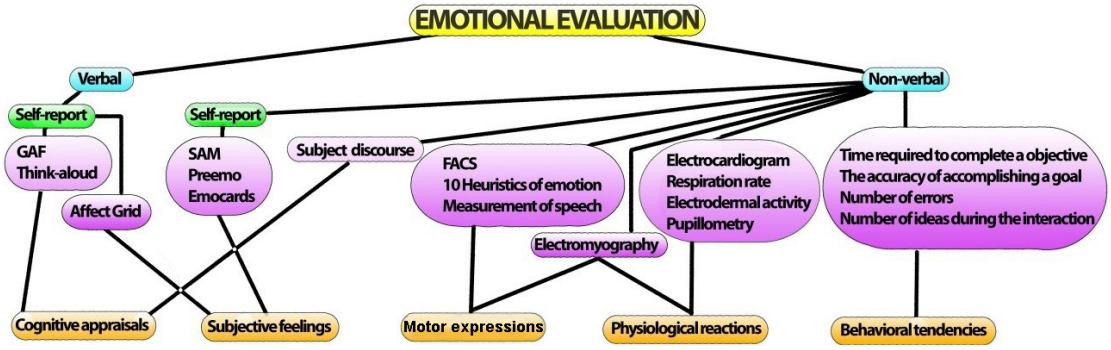

Figure 2: A taxonomy for emotional evaluation methods, techniques and tools.

The subjective feelings demand a self-report instrument, and we have selected the SAM (Lang, 1985) to measure it. The SAM is composed of three sets of figures that represent pleasure, arousal and dominance. Each dimension is evaluated using a scale ranging from 1-9 in which the user selects one circle. As a pictogram, it reduces the cultural differences, and as a non-verbal instrument, it avoids problems with the verbalization of emotions. Moreover, it considers the dominance aspect explicitly.

In our approach, we suggest that SAM be applied after the interaction with the system. The evaluator presents the instrument to the user and asks him/her to classify his/her experience by choosing one of the nine circles in each dimension (pleasure, arousal and dominance). Figure 3 illustrates the pictograms adopted by SAM for the pleasure dimension. The emotional response is considered positive if the user selects one of the circles indicated by the V+. The negative experience options are represented by V-, and the neutral experience is the central option and represented by VN. The final result can be reached for each dimension by adding the number of votes of all users in V+, VN and V-.

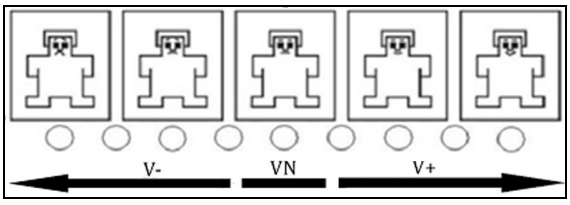

Figure 3: Pictograms adopted by the SAM questionnaire for measuring pleasure and the emotional values scales.

Following Mahlke and Mingue (2008), we have adopted effective and efficient metrics to measure the behavioral tendencies. They include the time required to complete a task and the number of errors or help requests, among others. Designers may not have difficulty collecting these metrics and evaluating if the final result is positive, negative or neutral, as they are commonly measured in traditional usability tests.

The physiological reactions can be assessed by sensors because they are related to neuroendocrine processes. The data should be collected during the interaction instead of only at the end of interaction. Moreover, the sensor should not disturb the user during the interaction. The results should be compared to baseline values established by the designers. If heart rate is collected, a baseline value could be 85 beats per minute. With a baseline value, designers can evaluate if the final result is positive, negative or neutral. However, sensors that can be used during the interaction, which save the data and do not disturb the user, are generally expensive.

The motor expressions component is assessed in our approach by the Ten Emotion Heuristics (Lera and Domingo, 2007), which are frowning, raising eyebrows, looking from a distance, smiling, compressing the lips, moving his mouth, vocal expressions, hand touching the face, going back to the chair and leaning the trunk forward. The evaluation is divided into two steps. In the first one, a group of pre-selected appraisers watch videos of the user's interaction. The videos can be captured by common webcams and should record the user's face and body.

For each heuristic identified, we recommend that the appraisers register the time it occurred, the task the user was doing, the heuristic or set of heuristics identified and a description of the emotional aspects. In the second step, the evaluators meet, discuss and build a final list containing the heuristics found. According to Lera and Domingo (2007), the final emotional experience evaluation is set as negative if five or more negative heuristics are found per user.

Because it is a heuristic evaluation, the collective common sense can identify the emotional experience of a group of users more accurately than an

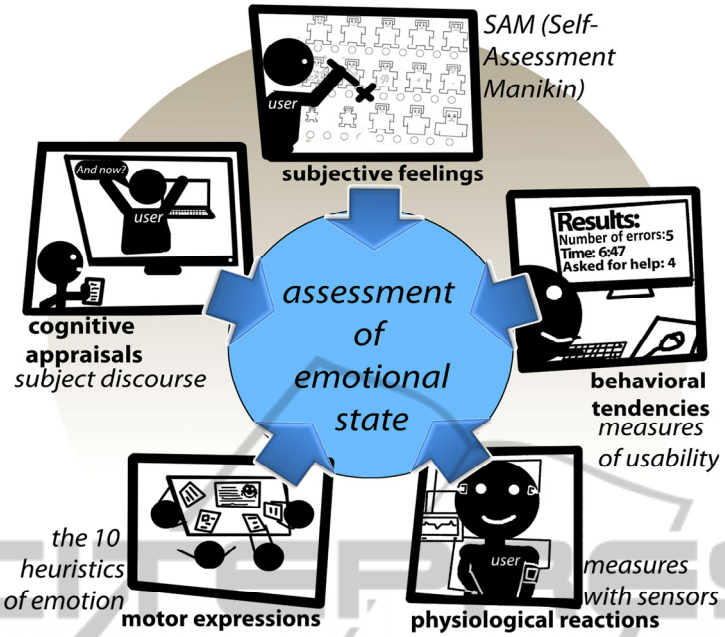

Figure 4: A hybrid approach for assessing the emotional state of users.

individual appraiser. Furthermore, facial recognition software is generally expensive, and FACS demands an experienced assessor to apply it properly.

The cognitive appraisals are measured by an adaptation of the Subjective Discourse Analysis (Lefevre and Lefevre, 2005). Using the same video as that recorded for the heuristic evaluation, the assessor lists key-expressions that were spoken spontaneously by the users during the interaction. Key expressions are central ideas that represent a synthesis of the discursive content, such as "And now?" or "Should I click here?". In addition to the expression, the assessor should add a description of the emotional situation in which that phrase was said, for example, in a moment of confusion, joy, or surprise. Thus, based on the description, the evaluator classifies the expression in terms of positive, neutral or negative.

After analyzing the videos and selecting the key expressions for each user, a final list of key expressions should be created. To be selected for the final list, a key expression should be used by more than one user. Finally, considering the most frequently spoken expressions and their classification as positive, negative or neutral, the designer can define the users' emotional response to that system considering the cognitive appraisals. Figure 4 shows the hybrid approach for assessing the emotional state of the users.

Applying the methods as described here, the designer has partial and complementary emotional responses of the users to the interaction with the information system. Considering the evaluation of each component, it is possible to reach a more comprehensive result and to decide if the information system creates a positive, neutral or negative emotional reaction in the users.

Table 1: Stakeholders and the final decision on the user's emotional response.

Scherer's component	Method	Stakeholder
Subjective feelings	SAM	User
Behavioral tendencies	Effective and efficient metrics	Designer
Physiological reactions	Sensors	User
Motor expressions	Ten Heuristics of Emotion	Group of designers
Cognitive appraisals	Subjective Discourse Analysis	Designer

Moreover, the results from each component support designers altering different aspects of the interface. Considering the most recurrent heuristic, for instance, it is possible to learn if the users are frustrated or confused. By SAM, it is possible to see if the users are excited but not confident, and by the sensor results, it is possible to see if the users are anxious. Finally, Table 1 presents the methods that are part of our approach and the stakeholder who makes the final decision regarding the user's

emotional response. We argue that these complementary views minimize the detection of false positives because we consider not only the information provided by users but also the designers' opinions to classify the emotional experiences.

The next section presents a feasibility study applying the proposed approach.

5 FEASIBILITY STUDY

Aiming to assess the feasibility of our hybrid approach, we selected a group of seven elderly users to evaluate a website about food and recipes using tablet devices. The evaluation occurred in the Social Reference Assistance Center (CRAS, in its Portuguese acronym) in São Carlos-SP, Brazil. The users were selected according to their age, education level and experience with devices and were asked to find a specific recipe, starting from the website home page. As the elderly users were not accustomed to using to tablet devices, one of the researchers acted as an active moderator, answering questions when the users asked for help.

Each user was filmed by two common cameras. One camera was focused on the user's body, and the other was registering the user's interaction with the device. After each interaction, the users were asked to fill in the SAM questionnaire. The users' selections were added in each dimension, and Table 2 summarizes the results. The pleasure dimension had a positive assessment with seven positive votes (V+). The arousal dimension was also ranked as positive with six positive votes (V+). On the other hand, the dominance dimension had a negative assessment with six negative votes (V-). The users reported that they had a pleasurable and exciting interaction but that they were not in the control of it.

Table 2: Results of the SAM assessment.

Pleasure			Arousal			Dominance		
V-	VN	V+	V-	VN	V+	V-	VN	V+
0	0	7	0	1	6	6	0	1

After the interaction experience, we applied the Ten Heuristics of Emotion method. The evaluation was performed by a group of six evaluators, including five from the computer science field and a professional nurse. The nurse was invited to join the group based on the idea that a professional from the health area could provide a complementary view in an evaluation with elderly users. One of the evaluators had experience in applying the method, and the others received one-hour of training. The final video, with all of the users, was 53 minutes and 41 seconds long. Figure 5 illustrates three different moments in the video and the heuristics identified.

Figure 5: Three examples of emotional heuristics.

In this feasibility study, three users had a positive experience with less than three different negative heuristics identified, and four had a negative experience with five or more negative heuristics identified. With a small number of users and a non-expressive difference in the final result, we classified the assessment of motor expressions as neutral.

The Subjective Discourse Analysis, as described in our approach, was applied by the researcher that acted as the moderator during the interaction. Analyzing the same video used to evaluate the heuristics, it was possible to identify the key statements made by the users in addition to their interaction context. The selected statements were classified as positive, neutral or negative. Furthermore, the most frequently spoken key statements were considered in the final cognitive appraisals evaluation. Table 3 summarizes the data collected.

Table 3: The most frequently spoken key expressions.

Key expressions	Interaction context	Experience	Number of users
Here?	Demonstrate doubt or do not know how to proceed in the task.	Negative	5
Recipes!	Realize where to click to accomplish the task.	Positive	4
And now?	Perform an action and do not know what will happen. It was also said in moments of frustration or when the user was confused.	Negative	4
I do not know.	Difficulty in understanding how the system works, how to interact, or when abandoning the activity.	Negative	3
I do not understand.	Feelings of confusion or disorientation due to do not knowing how the information was presented in the interface.	Negative	3

Checking the list of the top five spoken expressions, i.e., those most frequently stated by the users, we evaluated the cognitive appraisal as negative. The top five statements were chosen, and these statements were sufficient to indicate an emotional response tendency. If a non-clear tendency is reached in a study, designers should consider additional frequently spoken statements.

The behavioral tendencies were evaluated considering the number of times the users asked for help while interacting. As the expected interaction time was short (approximately two minutes), we considered that up to two solicitations for help would be classified as positive. Three solicitations for help were classified as neutral, and more than 3 solicitations were classified as negative. Two users had a positive behavioral tendency, and one user's tendency was classified as neutral. Four users asked for help more than three times, and their behavioral tendencies were classified as negative. The final result for this component was deemed negative.

The physiological measures were not evaluated in this feasibility study because of the high cost of the specific equipment and sensors required. Table 4 presents the final results of the website emotional evaluation.

Table 4: Results of the emotional assessment to the cooking site using the hybrid approach.

Scherer's component	Method	Evaluation
Subjective feelings	SAM- dimension of pleasure	Positive
	SAM- dimension of arousal	Positive
	SAM- dimension of dominance	Negative
Behavioral tendencies	Effective and efficient metrics	Negative
Physiological reactions	Sensors	Not applied
Motor expressions	Ten Heuristics of Emotion	Neutral
Cognitive appraisals	Subjective Discourse Analysis	Negative

Thus, an analysis of the results of each evaluation revealed that the emotional state of users while interacting with the website was classified as negative.

6 CRITICAL ANALYSIS AND LESSONS LEARNED

Using this hybrid approach, we were able to identify a set of relevant information about the emotional experience of users. For instance, applying the SAM questionnaire, it was possible to realize that even when elderly users do not have control over technology, the interaction can be pleasurable and excited. Other lessons learned include the following:

- Even in an evaluation of a user group with similar profile characteristics, there were variations in the users' emotional states.
- The users who were not familiar with the menus and search engines triggered a greater number of negative heuristics. This finding suggests a bad relationship between less experience and the emotional response, i.e., the less the user knows about the system interaction logic, the more negative is the emotional response to the interaction.
- The use of the Subjective Discourse Analysis allowed us to observe that some key statements are made by most of the users in similar interaction experiences. This observation suggests that affective systems could recognize these statements and change their user interfaces based on their occurrences.
- The evaluators who applied the Ten Heuristics of Emotion noted that the process of evaluating the heuristics requires a significant amount of time. "The method is inexpensive and fairly simple to run; however, it is difficult to achieve due to the large physical and cognitive effort required by the assessor", said one of the evaluators. Therefore, the

emotional evaluation performed used limited resources, but demanded time, especially of inexpert evaluators.

Finally, the proposed approach supports the evaluation of the users' emotional responses due to the interaction with information systems. The evaluation led to a final assessment of the system. However, the methods could also be applied to assess each user's emotional state. Therefore, through flexible and more accessible design solutions, users with low literacy levels and less experience with technology could have better emotional experiences.

7 CONCLUSIONS

This paper presented a hybrid approach to the emotional evaluation of information systems. The approach is based on Scherer's model (1984), and the evaluation methods were selected and adapted to measure the user's emotional response for the five components. A feasibility study was conducted considering a group of elderly users using tablet devices. The results suggest that the proposed approach can be easily applied, and moreover, it is relatively inexpensive.

The feasibility study also suggested that the approach is able to evaluate the users' emotional responses to the interaction, considering the software and the hardware used. In the elderly users' cases, less experience with tablets certainly influenced the final result. Moreover, the methods used also allowed the evaluation of a web information system. Future research can be performed to determine a better combination of methods for specific system domains. As Yusoff and Salim (2010) noted for games, for instance, there are various physiological features that can be measured and related to the emotional response.

Future work will consider applying this hybrid approach to identify the emotional state of young people and adults during the interaction with information systems in order to analyze the degree of emotional experience obtained between and among groups of users. Therefore, identifying the users' emotional states, we intend to improve the design solutions to create flexible interfaces that focus on satisfaction and emotional aspects of these users.

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